4 Water Quality Monitoring

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Introduction

The monitoring program for the Grassland Bypass Project (GBP), including water quality monitoring, is described in detail in Compliance Monitoring Program for the Use and Operation of the Grassland Bypass Project (USBR et al., 1996). This chapter provides a summary of the water quality monitoring program, modifications to the plan for the fifth year of operation of the GBP (October 1, 2000 to September 30, 2001), and water quality trends observed during five years of operation of the GBP. Detailed water quality data of individual monitoring stations will not be provided in this summary, as the San Francisco Estuary Institute (SFEI) has presented this information in another report (SFEI, 2002).

Monitoring Program

The Central Valley Regional Water Quality Control Board (CVRWQCB) has an on-going water quality monitoring program related to regulatory activities for agricultural subsurface drainage from the Grassland watershed. The water quality monitoring program for the GBP is an adaptation of the CVRWQCB monitoring program. The CVRWQCB conducts most of the water quality sampling, with assistance from the Panoche Drainage District (under contract with the San Luis & Delta-Mendota Water Authority (SLDMWA). The Panoche Drainage District collects samples at Stations A, J, K, L2, and M2. Samples are transferred to and processed by the CVRWQCB and analyzed by its contract laboratories. The CVRWQCB conducts quality assurance (QA) reviews of the data before submitting them to the SFEI for reporting. However, all CVRWQCB data are provisional and subject to change until the CVRWQCB approves its annual agency report on the water year (WY) 2001 monitoring results.

Monitoring Objectives

The water quality monitoring program was designed to provide data for evaluating compliance with commitments in the Project Waste Discharge Requirements, the Use Agreement, and associated documents. The commitments include:

- Monthly and annual selenium load limits on discharges
- No degradation of the San Joaquin River water quality relative to the pre-Project-condition
- Cessation of discharge of agricultural subsurface drainage to the wetland channels
- Management of flows in the San Luis Drain (SLD) so as to not mobilize channel sediments
- The Monitoring Program was also designed to verify the validity of assumptions expressed in documents associated with the GBP. The assumptions include:
- The GBP is expected to result in selenium concentrations less than 2 µg/L in approximately 93 miles of wetland water supply channels.
- The increased frequency of exceeding selenium water quality objectives in Mud Slough (north) will be offset by a reduction of exceedances in Salt Slough.

In addition, the Monitoring Program was intended to provide data to be used to assess spatial and temporal trends in water quality parameters of concern and to characterize habitats in which biological samples were collected.

Sampling Locations

Monitoring was to be conducted in four areas: the SLD, Mud Slough (north), the San Joaquin River, and the Grassland wetland water supply channels, including Salt Slough. Table 1 summarizes the Monitoring Program, and sampling locations are depicted in Figure 2 in Chapter 1.

Frequency of Sampling

The frequency of sampling is outlined in Table 1. Weekly composite samples were collected at Station A (inflow to the SLD). Daily composite samples were collected at Station B (discharge from the SLD), and at Station N (San Joaquin River at Crows Landing). At Station A, daily samples were composited into a weekly sample to be used along with continuous flow data to calculate weekly selenium load inflow to the SLD. At Station B, daily composite samples along with continuous flow data were used to calculate daily selenium load discharge to Mud Slough (north). At Station N, daily composite samples were collected to allow the CVRWQCB to calculate loads and evaluate progress toward compliance with Basin Plan water quality objectives. The compliance date at Station N for the selenium water quality objective (5 µg/L 4-day average) during normal and wet years is October 1, 2005, and during critical years is October 1, 2010 (CVRWQCB,

Table 1. Summary of Water Quality Monitoring Plan

Location	Site	Description	Purpose	Analytical Parameter	Frequency	Sampling Methodology
San Luis Drain	A	inflow to SLD	water quality of inflow (Se and TSS)	Se, B, EC	weekly composite	auto-sampler
				EC, TSS	weekly	mid-channel, depth integrated
	B	discharge from SLD	water quality of discharge (Se and TSS) (for Se load calculation)	Se, B, EC	daily composite	auto-sampler
				Se, B, EC, TSS	weekly	mid-channel, depth integrated
Mud Slough (north)	C	upstream of SLD discharge	Mud Slough (north) base water quality prior to receiving drainage discharges	Se, B, EC	weekly	grab
	D	downstream of discharge	Mud Slough (north) water quality as impacted by drainage discharge	Se, B, EC	weekly	mid-channel, depth integrated
	I/I2	back water	water quality impact of Mud Slough (north) flooding in Kesterson Refuge	Se, B, EC	annually	N/A
Wetland Channels	F	Salt Slough	water quality of habitat and to track improvements in former drainage conveyance channel	Se, B, EC	weekly	grab
	J	Camp 13	verify no discharge of drainage provision	Se, B, EC	weekly	grab
	K	Agatha Canal	verify no discharge of drainage provision	Se, B, EC	weekly	grab
	L2	San Luis Canal	water quality of wetland water supply channel	Se, B, EC	weekly	grab
	M2	Santa Fe Canal	water quality of wetland water supply channel	Se, B, EC	weekly	grab
San Joaquin River	G	at Fremont Ford (upstream of drainage inflow)	track improvements in former drainage conveyance channel and characterize water quality of habitat	Se, B, EC	weekly	grab
	H	at Hill's Ferry (downstream of drainage inflow)	intended to represent water quality of river most impacted by drainage discharge	Se, B, EC	discontinued; determined to be downstream of seasonal Merced River inflows	grab
	N	at Crows Landing (downstream of Merced River confluence)	characterize water quality of habitat	Se, B, EC Se, B, EC	daily composite weekly	auto-sampler grab

1998a). Since the objective is based on a 4-day average concentration, consecutive daily samples are required at this station. The remaining stations were sampled on a weekly basis.

Sampling Methodology

Three types of sampling techniques were utilized, depending on the frequency of sampling and data needs: auto-sampler, mid-channel depth-integrated, and grab sample from channel bank. Auto-samplers were used to collect daily and weekly composite samples because of the remoteness of the station and frequency of sampling. At Stations A, B, and D, structures such as a bridge or platform over the channel permitted the collection of mid-channel, depth-integrated samples. At other stations, a grab sample was collected from the stream bank. With respect to stream hydrology, lateral and vertical homogeneity was assumed for dissolved constituents at all sampling stations.

Modifications to the Water Quality Monitoring Program

During the previous four years of the GBP, a number of issues were resolved with respect to the water quality monitoring program. These modifications and clarifications to the monitoring program are discussed in the first four Annual Reports (USBR, 1998 and SFEI, 1999, 2000, and 2001).

During the fourth year of the GBP it was decided that water quality monitoring at Station H would be conducted by the SLDMWA. The results of the monitoring would be used in conjunction with the biological monitoring portion of the GBP. As the data were collected separate from the water quality monitoring program, the data are not included in this chapter. The data are presented in Chapter 1 of this report.

Water Quality Trends

Detailed water quality data for each monitoring station are presented in the Grassland Bypass Project Annual Narrative and Graphical Summary, October 2000 to September 2001 (SFEI, 2002). Thus, this presentation will be limited to major water quality trends and findings for the five years of operation of the GBP. Of primary interest are selenium concentrations in the San Joaquin River and water quality trends in Mud Slough (north). Also of interest are sporadic exceedances in the wetland channels of selenium water quality objectives established in the Water Quality Control Plan for the Sacramento/San Joaquin River Basins.

San Joaquin River

The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) contains a schedule for compliance with the 5 µg/L (4-day average) selenium water quality objective and performance goals. The compliance date is either October 1, 2005 or October 1, 2010, depending on water year type (wet, dry, etc.) (Table 2). Compliance with selenium water quality objectives and performance goals specified in the Basin Plan is measured at Station N.

Figure 1 depicts selenium concentrations in the San Joaquin River at monitoring Stations G (weekly grab) and N (4-day average) for WYs 1997 through 2001. The water quality objective is depicted in Figure 1 for comparison purposes. Station G is located at Fremont Ford, upstream of the Mud Slough (north) inflow to the San Joaquin River. Because this station is located upstream of drainage discharges from the GBP service area (except during flood events when drainage has occasionally been routed to Salt Slough), selenium concentrations are relatively low, and have remained below 2 µg/L since the beginning of the GBP.

Station N is located downstream of the GBP discharges conveyed by Mud Slough (north) and the Merced River inflow to the San Joaquin River. Merced River inflows dilute the upstream selenium contributions (CVRWQCB, 2002). Selenium concentrations frequently exceeded a 5 µg/L (4-day average) during WY 1997, but remained below 10 µg/L. In contrast, selenium concentrations remained below a 5 µg/L (4-day average) during WY 1998. During WY 1999, selenium concentrations exceeded a 5 µg/L (4-day average) during the months of June, July, and August, but remained below 7 µg/L. During WY 2000, selenium concentrations exceeded a 5 µg/L (4-day average) during the month of June, but remained below 6µg/L. During WY 2001, selenium concentrations were above 5µg/L for short periods of time during the months of March, April, June and July. The maximum concentration observed in the San Joaquin River was 5.9 µg/L at Station N on June 16.

On October 1, 2002 a performance goal of either 5 µg/L or 8 µg/L monthly mean selenium concentration (depending on water year type) becomes effective in the San Joaquin River below the confluence with the Merced River. Figure 2 depicts monthly mean selenium concentrations at Station N for WYs 1997 through 2001. With

Figure 1. Selenium Concentration in the San Joaquin River, Water Years 1997 through 2001

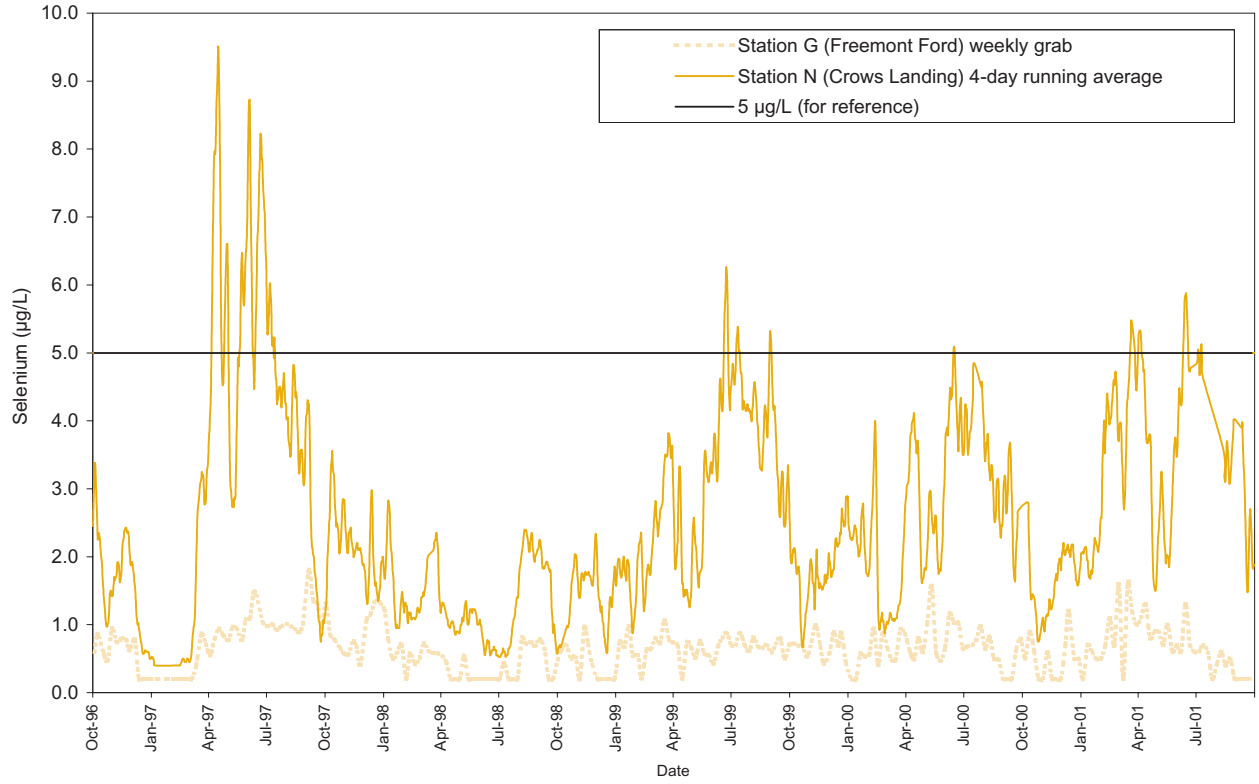


Table 2. Summary of Selenium Water Quality Objectives and Compliance Time Schedule

[Selenium Water Quality Objectives (in bold) and Performance Goals (in italics)]

Water Body/Water Year Type [1]	1 October, 1996	1 October, 2002	1 October, 2005	1 October, 2010
San Joaquin River below the Merced River; Above Normal, and Wet Water Year Types		*5 µg/L monthly mean*	***5 µg/L 4-day average***	
San Joaquin River below the Merced River; Critical, Dry, and Below Normal Water Year Types		*8 µg/L monthly mean*	*5 µg/L monthly mean*	***5 µg/L 4-day average***
San Joaquin River from Sack Dam to the Merced River				***5 µg/L 4-day average***

[1] The water year classification will be established using the best available estimate of the 60-20-20 San Joaquin Valley water year hydrologic classification (as defined in Footnote17 for Table 3 in the State Water Resources Control Board's *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* , May 1995) at the 75% exceedance level using data from the Department of Water Resources Bulletin 120 series. The previous water year's classification will apply until an estimate is made of the current water year.

the exception of two months during the wet Water Year 1997, monthly mean selenium concentrations have not exceeded 5 µg/L at Station N. Starting on October 1, 2002, the applicable performance goal for a dry year, such as WY 2001, will be an 8 µg/L monthly mean selenium concentration. Monthly mean selenium concentrations during WY 2001 did not exceed 5µg/L. Thus, it appears that the GAF have demonstrated the capability of meeting these performance goals ahead of schedule.

The Basin Plan and the GBP Waste Discharge Requirements (WDRs) prohibit discharge of selenium from agricultural subsurface drainage systems in the Grassland Watershed to the San Joaquin River in amounts exceeding 8,000-pounds per year. Calculations using daily selenium data, preliminary USGS flow data, and the load calculation methods found in CVRWQCB (1998b) indicate that the annual selenium load measured at Station N during WY 2001 was well below the 8,000-pound annual load limit for the Grassland Watershed.

Wetland Channels

Monthly mean selenium concentrations in the wetland channels for WY 2001 are depicted in Figure 3. The monthly mean 2 µg/L selenium objective was met during all months in Salt Slough. The monthly mean 2µg/L selenium objective was exceeded in March and April at Station J, February through April at Station K, November through April at Station L2, and February and April at Station M2. The maximum observed monthly mean concentrations of 4.1 µg/L at Station J, 5.1 µg/L at Station K, 4.5 µg/L at Station L2, and 2.7 µg/L at Station M2, however, are substantially lower than pre-Project concentrations (CVRWQCB, 1998c).

Regional Board staff conducted preliminary investigations on the potential sources of selenium, which are detailed in two separate reports (CVRWQCB, 2000 and CVRWQCB, 2002). In summary, primary sources of selenium to the channels were determined to be diversions from the 94,000-acre Drainage Project Area (DPA) (both stormwater flows and seepage from control gates), supply water, subsurface agricultural drainage from areas outside of the DPA, tailwater and local groundwater. To address the first source, diversions from the DPA, the Grassland Area Farmers (GAF) developed a stormwater management plan, and internal control gates were sealed. These actions appear to have controlled peaks of selenium previously observed during storm events.

Despite the stormwater management plan and control gate modifications made by the GAF, selenium concentrations have continued to sporadically exceed the 2µg/l monthly mean selenium objective in the wetland

Figure 2. Monthly Mean Selenium Concentration at Crows Landing, Water Years 1997 through 2001

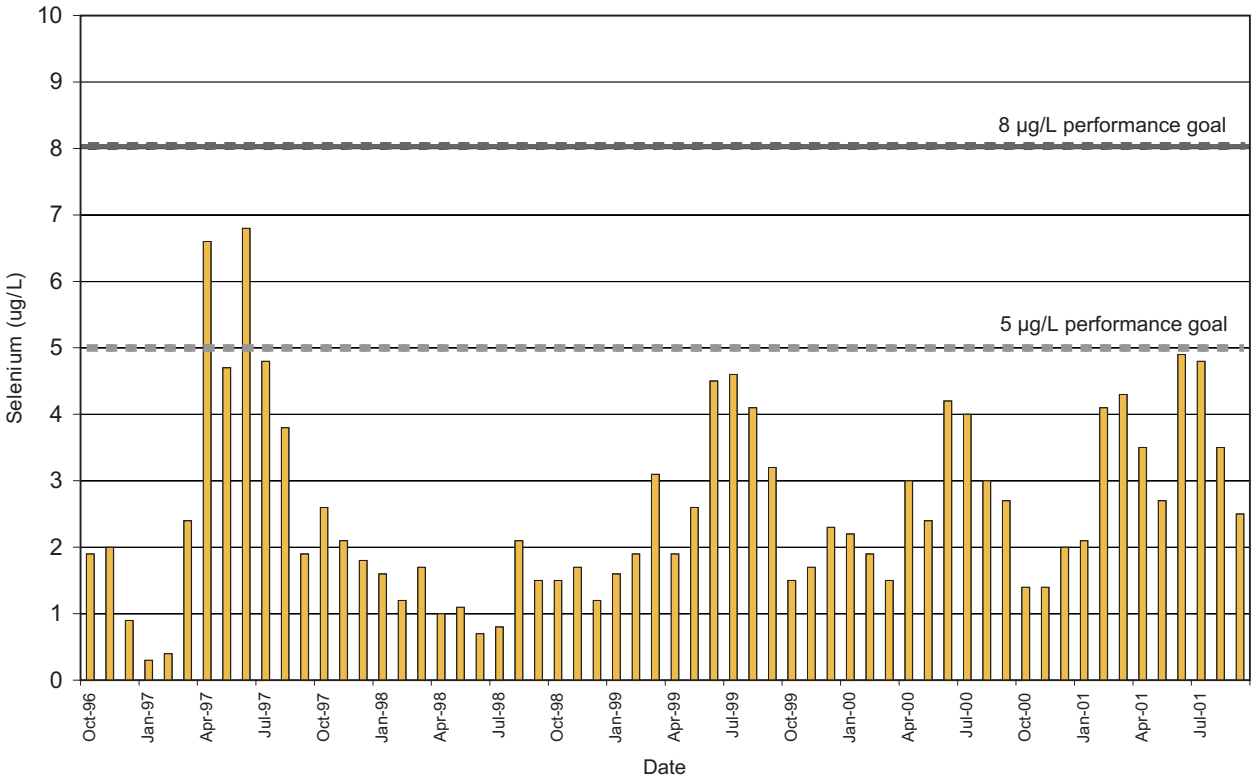


Figure 3. Mean Monthly Selenium Concentration in the Wetland Channels October 1, 2000 to September 30, 2001

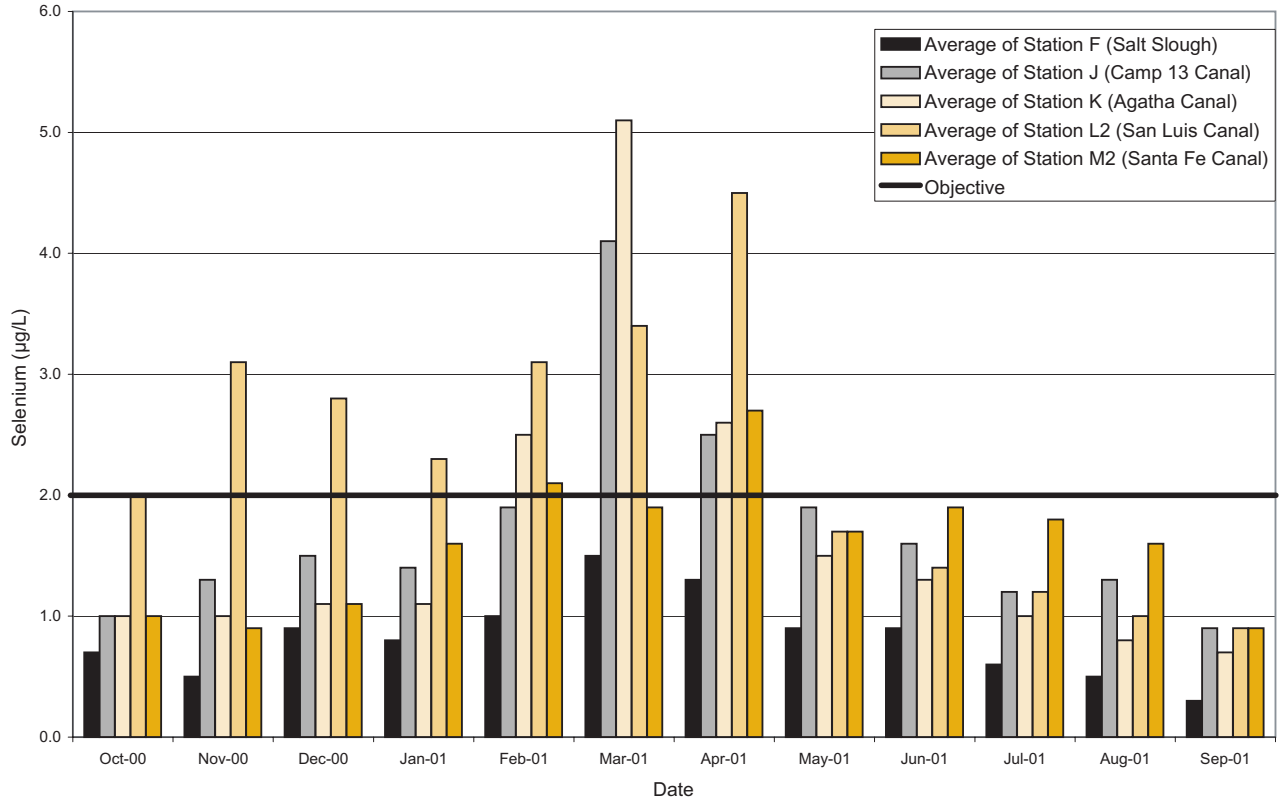
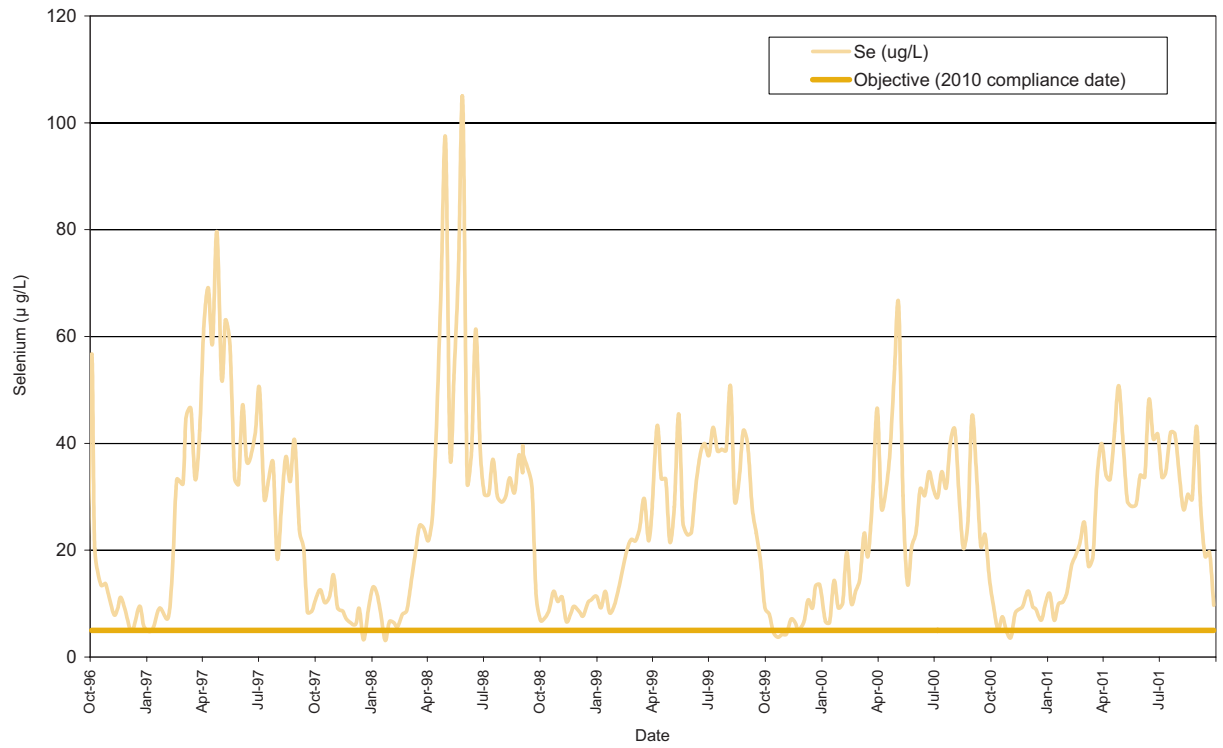


Figure 4. Selenium Concentration in Mud Slough (north) downstream of SLD WYs 1997 through 2001



channels, particularly from the pre-irrigation season through the early irrigation season (February through April). As a result of the continued elevated selenium concentrations, staff focused the ongoing investigations on potential selenium sources outside of the GBP area: supply water and subsurface agricultural drainage from outside of the GBP service area. Results are currently under review and will be used to direct the ongoing investigation during Water Year 2002.

Mud Slough (North)

Results of weekly grab sampling for selenium at Station D, Mud Slough (north) downstream of the SLD, are depicted in Figure 4. Selenium concentration distributions as a function of time were similar for all water years. Selenium concentrations tend to be lowest from the fall through early winter (non-irrigation period) and highest during the irrigation period, which commences in mid winter (pre-plant irrigation) and lasts through the summer. During Water Year 2001, selenium concentrations in Mud Slough (north) downstream of the SLD ranged from 3.7 µg/L in November, to 50.8 µg/L in April. Water quality in Mud Slough (north) downstream of the SLD is dominated by the GBP drainage discharge. For comparison purposes, the 5 µg/L (4-day average) selenium water quality objective, which applies October 1, 2010 for Mud Slough (north), is noted on Figure 4. Selenium concentrations regularly exceeded 5 µg/L in Mud Slough (north) downstream of the SLD inflow. Upstream of the drainage discharge, the concentration of selenium was usually below 2 µg/L, and the maximum observed selenium concentration was 2.2µg/L (Figure 5).

Boron Water Quality Objectives

Mean monthly boron objectives and WY 2001 boron concentrations for Mud Slough, Salt Slough, and the San Joaquin River are depicted in Table 3. Exceedances of the 2.0 mg/L objective occurred at Station C in April and at Station D from March through September. The 1.0 mg/L objective was exceeded at Station N during February and March, and the 0.8 mg/L objective was exceeded at Station N during March and April and from June through August. Sources of boron extend throughout the San Joaquin Basin and are not restricted to the GBP (CVRWQCB, 2002). The CVRWQCB is concurrently conducting a separate effort to control salt and boron loading to the lower San Joaquin Basin.

Conclusions

Five years of GBP monitoring have shown that selenium concentrations in the San Joaquin River are a function of location in the River with respect to discharge points and tributary inflows, and of the assimilative capacity of the River. The lowest selenium concentrations in the San Joaquin River are upstream of Mud Slough (north) inflows. Mud Slough (north) inflow contains relatively high concentrations of selenium. The Merced River dilutes the San Joaquin River with respect to selenium. Selenium concentrations in the San Joaquin River at Station N, however, remain elevated relative to the background condition in the San Joaquin River at Station G.

The 2 µg/L monthly mean selenium water quality objective was exceeded in four of the wetland supply channels during WY 2001. The maximum monthly mean observed was 5.1µg/L at Station K (Agatha Canal) in March. A number of sources may contribute to the exceedances of selenium water quality objectives in the wetland channels, including agricultural subsurface drainage from areas outside the GBP being discharged to the channels upstream of the wetlands. CVRWQCB staff is conducting ongoing investigations focusing on identifying sources of selenium that contribute to exceedances of the selenium water quality objective in the wetland supply channels. The results of these investigations are detailed in separate reports that are available from the Regional Board. The CVRWQCB is evaluating control actions to reduce selenium concentrations in the wetland channels.

The water quality of Mud Slough (north) downstream of the SLD inflow is governed by the GBP drainage discharge and fluctuates widely. Selenium concentrations tend to be lowest from the fall through early winter (non-irrigation period) and highest during the irrigation period, which commences in mid winter (pre-plant irrigation) and lasts through the summer. Selenium concentrations regularly exceeded 5 µg/L in Mud Slough (north) downstream of the SLD inflow, and reached an observed maximum concentration of 50.8 µg/L in April 2001. Upstream of the drainage discharge, the concentration of selenium was usually below 2 µg/L.

References

CVRWQCB. 1998a. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region, Fourth Edition: The Sacramento River Basin and the San Joaquin River Basin. California Regional Water Quality Control Board, Central Valley Region. Sacramento, CA.

CVRWQCB. 1998b. Loads of Salt, Boron, and Selenium in the Grassland Watershed and Lower San Joaquin River October 1985 to September 1995 – Volume I: Load Calculations. California Regional Water Quality Control Board, Central Valley Region. Sacramento, CA.

CVRWQCB. 1998c. Compilation of Electrical Conductivity, Boron, and Selenium Water Quality Data for the Grassland Watershed and San Joaquin River (May 1985 – September 1995), February 1998. California Regional Water Quality Control Board, Central Valley Region. Sacramento, CA.

CVRWQCB. 2000. Review of Selenium Concentrations in Wetland Water Supply Channels in the Grassland Watershed, May 2000. California Regional Water Quality Control Board, Central Valley Region. Sacramento, CA.

CVRWQCB. 2002. Water Quality of the Lower San Joaquin River: Lander Avenue to Vernalis October 1998 - September 2000 (Water Years 1999 and 2000). California Regional Water Quality Control Board, Central Valley Region. Sacramento, CA.

Table 3. Boron Water Quality Objective Exceedances in the Grassland Watershed and San Joaquin River: Water Year 2001.

Station ID	Description	Mean Monthly Concentration (mg/L)												Monthly WQO
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
C	Mud Slu (N) upstrm of SLD Discharge	a	a	a	a	a	**2.0**	**2.2**	**1.3**	**2.0**	**1.8**	**1.5**	**0.67**	2.0
D	Mud Slu (N) dwnstrm of SLD Discharge	a	a	a	a	a	**4.0**	**5.2**	**4.7**	**6.4**	**6.1**	**5.3**	**4.8**	2.0
F	Salt Slough at Lander Avenue	a	a	a	a	a	**1.0**	**0.94**	**0.56**	**0.50**	**0.53**	**0.46**	**0.68**	2.0
G	SJR at Fremont Ford	a	a	a	a	a	**0.60**	**0.80**	**0.58**	**0.50**	**0.56**	**0.45**	**0.68**	2.0
N	SJR at Crows Landing Weekly Grab Samples	**0.40**	**0.47**	**0.72**	**0.84**	**1.1**	**1.1**	**0.87**	**0.58**	**1.0**	**1.1**	**1.0**	**0.77**	1.0/0.8[1]
N	SJR at Crows Landing Daily Autosamples	**0.41**	**0.50**	**0.73**	**0.85**	**1.1**	**1.1**	**0.83**	**0.59**	**1.1**	**1.2**	**1.0**	**0.73**	1.0/0.8[1]

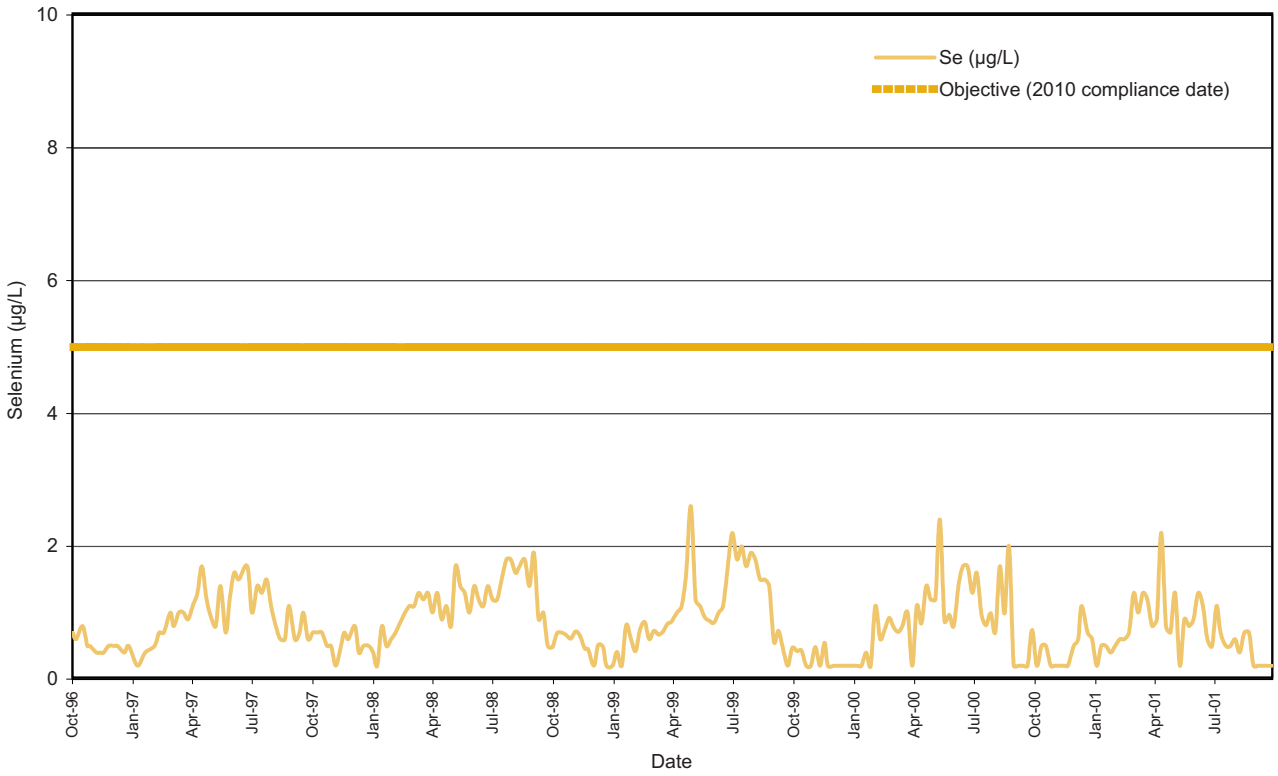
= water quality objective exceedance

WQO = water quality objective in mg/L

a = objective only applies 15 March through 15 September

[1] = 1.0 mg/L applies 16 September through 14 March
0.8 mg/L applies 15 March through 15 September

Figure 5. Weekly Grab Selenium Concentration at Station C (Mud Slough (north) upstream of SLD) for WYs 1997, 1998, 1999, 2000, and 2001



CVRWQCB. 2002. Review of Selenium Concentrations in Wetland Water Supply Channels in the Grassland Watershed, April 2002. California Regional Water Quality Control Board, Central Valley Region. Sacramento, CA.

San Francisco Estuary Institute (SFEI). 1999. Grassland Bypass Project Annual Report, October 1, 1997 to September 30, 1998. Richmond, CA.

San Francisco Estuary Institute (SFEI). 2000. Grassland Bypass Project Annual Report, October 1, 1998 to September 30, 1999. Richmond, CA.

San Francisco Estuary Institute (SFEI). 2001. Grassland Bypass Project Annual Report, October 1, 1999 to September 30, 2000. Richmond, CA.

San Francisco Estuary Institute (SFEI). 2002. Grassland Bypass Project Annual Narrative and Graphical Summary, October 2000 to September 2001. Richmond, CA.

U.S. Bureau of Reclamation et al. 1996. Compliance Monitoring Program for the Use and Operation of the Grassland Bypass Project, September 1996. U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

U.S. Bureau of Reclamation. 1998. Grassland Bypass Project Annual Report. October 1, 1996 through September 30, 1997. U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.